Calculation Examples

BMP Clearing House

Chesapeake Bay Program

Exampleville

Service Area Includes:

- 6656 Total Regulated Acres
- 2272.7 Impervious Acres
- 4383.3 Pervious Acres

Table 2a: Calculation Sheet for Estimating Existing Source Loads for the James River Basin *Based on Chesapeake Bay Program Watershed Model Phase 5.3.2

Subsource	Pollutant	Total Existing Acres Served by MS4 (6/30/09)	2009 EOS Loading Rate (lbs/acre)	Estimated total POC Load Based on 2009 Progress Run
Regulated Urban Impervious	Nitrogen	2272.7	9.39	21340.7
Regulated Urban Pervious		4383.3	6.99	30639.3
Regulated Urban Impervious	Phosphorus	2272.7	1.76	4000
Regulated Urban Pervious		4383.3	0.5	2191.7
Regulated Urban Impervious	Total Suspended Solids	2272.7	676.94	1538481.5
Regulated Urban Pervious		4383.3	101.08	443064

Table 3a: Calculation Sheet for Determining Total POC Reductions Required During this Permit Cycle for the James River Basin
*Based on Chesapeake Bay Program Watershed Model Phase 5.3.2

Subsource	Pollutant	Total Existing Acres Served by MS4 (6/30/09)	First Permit Cycle Required Reduction in Loading Rate (lbs/acre)	Total Reduction Required First Permit Cycle(lbs)/yr
Regulated Urban Impervious	Nitrogen	2272.7	0.04	90.9
Regulated Urban Pervious		4383.3	0.02	87.7
Regulated Urban Impervious	Phosphorous	2272.7	0.01	22.7
Regulated Urban pervious		4383.3	0.002	8.8
Regulated Urban Impervious	Total Suspended Solids	2272.7	6.67	15158.9
Regulated Urban Pervious		4383.3	0.44	1928.7

1st Permit Cycle Total Reductions Required

- Based on Table 3a
- Nitrogen: 90.9 lbs + 87.7 lbs = 178.6 lbs
- Phosphorous: 22.7 lbs + 8.8 lbs = 31.5 lbs
- TSS : 15158.9 lbs + 1928.7 lbs = 17087.6 lbs

Efficiency Calculations

Three ways of calculating BMP POC reductions

1. Utilize BMP Clearinghouse data

2. Utilize Chesapeake Bay Program data

3. Utilize Chesapeake Bay Program Retrofit Curves

Virginia Stormwater BMP Clearinghouse Established Efficiencies

- Efficiencies up to date as of publication of Guidance
- If there is a discrepancy between this table and the website, the efficiencies on website supersede the guidance table
- There are no Bay Program equivalent efficiency BMPs for Rooftop Disconnection and Rainwater Harvesting. Permittees must use the Clearinghouse values to receive credit
- Can be used as long as the BMP design criteria are met

Practice Number	Practice	TN	TP
1	Rooftop Disconnection[13]	25% or 50%[1]	25% or 50%[1]
2	Sheetflow to Vegetated Filter or Conserved Open Space 1	25% or 50%[1]	25% or 50%[1]
	Sheetflow to Vegetated Filter or Conserved Open Space 2	50% or 75%[1]	50% or 75%[1]
3	Grass Channel	28%	23%
5	Vegetated Roof 1	45%	45%
	Vegetated Roof 2	60%	60%
6	Rainwater Harvesting	Up to 90%	Up to 90%
7	Permeable Pavement 1	59%	59%
	Permeable Pavement 2	81%	81%
8	Infiltration 1	57%	63%
	Infiltration 2	92%	93%
9	Bioretention 1	64%	55%
	Bioretention 2	90%	90%
	Urban Bioretention	64%	55%
10	Dry Swale 1	55%	52%
	Dry Swale 2	74%	76%
11	Wet Swale 1	25%	20%
	Wet Swale 2	35%	40%
12	Filtering Practice 1	30%	60%
	Filtering Practice 2	45%	65%
13	Constructed Wetland 1	25%	50%
	Constructed Wetland 2	55%	75%
14	Wet Pond 1	30% (20%)[2]	50% (45%)[2]
	Wet Pond 2	40% (30%)[2]	75% (65%)[2]
15	Extended Detention Pond 1	10%	15%
	Extended Detention Pond 2	24%	31%

Practice Number	Practice	TN	TP
1	Rooftop Disconnection[13]	25% or 50%[1]	25% or 50%[1]
2	Sheetflow to Vegetated Filter or Conserved Open Space 1	25% or 50%[1]	25% or 50%[1]
	Sheetflow to Vegetated Filter or Conserved Open Space 2	50% or 75%[1]	50% or 75%[1]
3	Grass Channel	28%	23%
5	Vegetated Roof 1	45%	45%
	Vegetated Roof 2	60%	60%
6	Rainwater Harvesting	Up to 90%	Up to 90%
7	Permeable Pavement 1	59%	59%
	Permeable Pavement 2	81%	81%
8	Infiltration 1	57%	63%
	Infiltration 2	92%	93%
9	Bioretention 1	64%	55%
	Bioretention 2	90%	90%
	Urban Bioretention	64%	55%
10	Dry Swale 1	55%	52%
	Dry Swale 2	74%	76%
11	Wet Swale 1	25%	20%
	Wet Swale 2	35%	40%
12	Filtering Practice 1	30%	60%
	Filtering Practice 2	45%	65%
13	Constructed Wetland 1	25%	50%
	Constructed Wetland 2	55%	75%
14	Wet Pond 1	30% (20%)[2]	50% (45%)[2]
	Wet Pond 2	40% (30%)[2]	75% (65%)[2]
15	Extended Detention Pond 1	10%	15%
	Extended Detention Pond 2	24%	31%

Chesapeake Bay Program BMPs	TN	TP	TSS
Wet Ponds and Wetlands	20%	45%	60%
Dry Detention Ponds and Hydrodynamic Structures	5%	10%	10%
Dry Extended Detention Ponds	20%	20%	60%
Infiltration Practices w/o Sand, Veg.	80%	85%	95%
Infiltration Practices w/ Sand, Veg.	85%	85%	95%
Filtering Practices	40%	60%	80%
Bioretention C/D soils, underdrain	25%	45%	55%
Bioretention A/B soils, underdrain	70%	75%	80%
Bioretention A/B soils, no underdrain	80%	85%	90%
Vegetated Open Channels C/D soils, no underdrain	10%	10%	50%
Vegetated Open Channels A/B soils, no underdrain	45%	45%	70%
Bioswale	70%	75%	80%
Permeable Pavement w/o Sand, Veg. C/D soils, underdrain	10%	20%	55%
Permeable Pavement w/o Sand, Veg. A/B soils, underdrain	45%	50%	70%
Permeable Pavement w/o Sand, Veg. A/B soils, no underdrain	75%	80%	85%
Permeable Pavement w/Sand, Veg. C/D soils, underdrain	20%	20%	55%
Permeable Pavement w/Sand, Veg. A/B soils, underdrain	50%	50%	70%
Permeable Pavement w/Sand, Veg. A/B soils, no underdrain	80%	80%	85%
Street Sweeping Mass Reduced per pound of sediment swept	0.18%	0.07%	100%

Wet Pond Level 1

- Design meets the wet pond level 1 Virginia BMP Clearinghouse design criteria
- Located in a coastal area – see numbers in parentheses
- Removal Efficiencies:

POC	Clearinghouse	Chesapeake Bay Program Established Efficiencies
Nitrogen (N)	30% (20%)	20%
Phosphorous (P)	50% (45%)	45%
Sediment(TSS)	N/A	60%

Wet Pond Level 1

- Design meets the Wet Pond level 1 Virginia BMP Clearinghouse design criteria
- Located in a coastal area – see numbers in parentheses
- Removal efficiencies :

POC	Clearinghouse	Chesapeake Bay Program Established Efficiencies
Nitrogen (N)	30% (20%)	20%
Phosphorous (P)	50% (45%)	45%
Sediment(TSS)	N/A	60%

- Because the BMP is located in a coastal area, the coastal area efficiencies must be used

Wet Pond Level 1

- Wet pond drainage area
  - 22 acres total – all within regulated area
  - 7.5 acres impervious
  - 14.5 acres pervious

Wet Pond Level 1

Use the 2009 EOS loading rates from Table 2a

Nitrogen impervious loading:

7.5 acres * 9.39 lbs/acre/yr = 70.4 lbs/yr

Nitrogen pervious loading:

14.5 acres * 6.99 lbs/acre/yr = 101.4 lbs/yr

Wet Pond Level 1

Nitrogen Removal Efficiency Calculation – performed the same way if using the Clearinghouse data or the Chesapeake Bay Program Established Efficiency data

(In this case the Clearinghouse and Chesapeake Bay tables give identical removal numbers)

Impervious: 70.4 lbs/yr * 0.20 = 14.1 lbs/yr

Pervious: 101.4 lbs/yr * 0.20 = 20.3 lbs/yr

Total Nitrogen removed by this BMP:

14.1 lbs/yr + 20.3 lbs/yr = 34.4 lbs/yr

Wet Pond Level 1

Use the 2009 EOS loading rates from Table 2a

Phosphorous impervious loading:

7.5 acres * 1.76 lbs/acre/yr = 13.2 lbs/yr

Phosphorous pervious loading:

14.5 acres * 0.5lbs/acre/yr = 7.3 lbs/yr

Wet Pond Level 1

Phosphorous Removal Efficiency Calculation – performed the same way if using the Clearinghouse data or the Chesapeake Bay Program Established Efficiency data

(In this case the Clearinghouse and Chesapeake Bay tables give identical removal numbers)

Impervious: 13.2 lbs/yr * 0.45 = 5.9 lbs/yr

Pervious: 7.3 lbs/yr * 0.45 = 3.3 lbs/yr

Total Phosphorous removed by this BMP:

5.9lbs/yr + 3.3 lbs/yr = 9.2 lbs/yr

Remaining Reductions Required

- Total Nitrogen reduction required: 178.6 lbs/yr

  178.6lbs/yr – 34.4lbs/yr = 144.2 lbs/yr

- Total Phosphorous reduction required: 31.5 lbs/yr

  31.5 lbs/yr -9.2 lbs/yr = 22.3 lbs/yr

What About TSS???

- BMP Clearinghouse does not have TSS removal efficiencies (the Chesapeake Bay Established Efficiency Table does have TSS removal efficiencies)

- To estimate the TSS removal efficiency, for the BMP Clearinghouse, use the Chesapeake Bay Program Retrofit Curves

Chesapeake Bay Retrofit Curves

- Use to find TSS removal efficiency if utilizing the Clearinghouse data for Phosphorous and Nitrogen
- Use for all POCs if Clearinghouse/Chesapeake Bay Program design criteria can't be met

Chesapeake Bay Retrofit Curves – cont.

- Runoff Depth (RD) treated per impervious acre needs to be estimated to utilize the curves
- This can be done by several ways
  - Obtain from engineering calculations or the designing engineer
  - Have the designing engineer provide an estimate for runoff storage (RS) and plug that number into an equation
  - Get the RS estimate from the Runoff Reduction Spreadsheet (only works if BMP selected is classified as a runoff reduction practice)

Runoff Reduction Spreadsheet

	channels	reduction	0.30	0.00	0	0
5. Dry Swale						
5.a. Dry Swale #1 (Spec #10)	impervious acres draining to dry swale	40% runoff volume reduction	0.40	0.00	0	0
	turf acres draining to dry swale	40% runoff volume reduction	0.40	0.00	0	0
5.b. Dry Swale #2 (Spec #10)	impervious acres draining to dry swale	60% runoff volume reduction	0.60	0.00	0	0
	turf acres draining to dry swale	60% runoff volume reduction	0.60	0.00	0	0
6. Bioretention						
6.a. Bioretention #1 or Urban Bioretention (Spec #9)	impervious acres draining to bioretention	40% runoff volume reduction	0.40	1.84	0	2538
	turf acres draining to bioretention	40% runoff volume reduction	0.40	0.15	0	48
6.b. Bioretention #2 (Spec #9)	impervious acres draining to bioretention	80% runoff volume reduction	0.80	0.00	0	0
	turf acres draining to bioretention	80% runoff volume reduction	0.80	0.00	0	0
7. Infiltration						
7.a. Infiltration #1 (Spec #8)	impervious acres draining to infiltration	50% runoff volume reduction	0.50	0.00	0	0
	turf acres draining to infiltration	50% runoff volume reduction	0.50	0.00	0	0
7.b. Infiltration #2 (Spec #8)	impervious acres draining to infiltration	90% runoff volume reduction	0.90	0.00	0	0
	turf acres draining to infiltration	90% runoff volume reduction	0.90	0.00	0	0

Runoff Reduction Spreadsheet – cont.

- Add the numbers shown in Cell I from tab DA for the selected practice.
- Convert from cubic feet (cf) to acre-feet
- RS = 0.06 acre-feet
- This method only works if the BMP selected is classified as a runoff reduction practice

Runoff Depth Equation

$$RD = \frac{(RS)(12)}{IA}$$

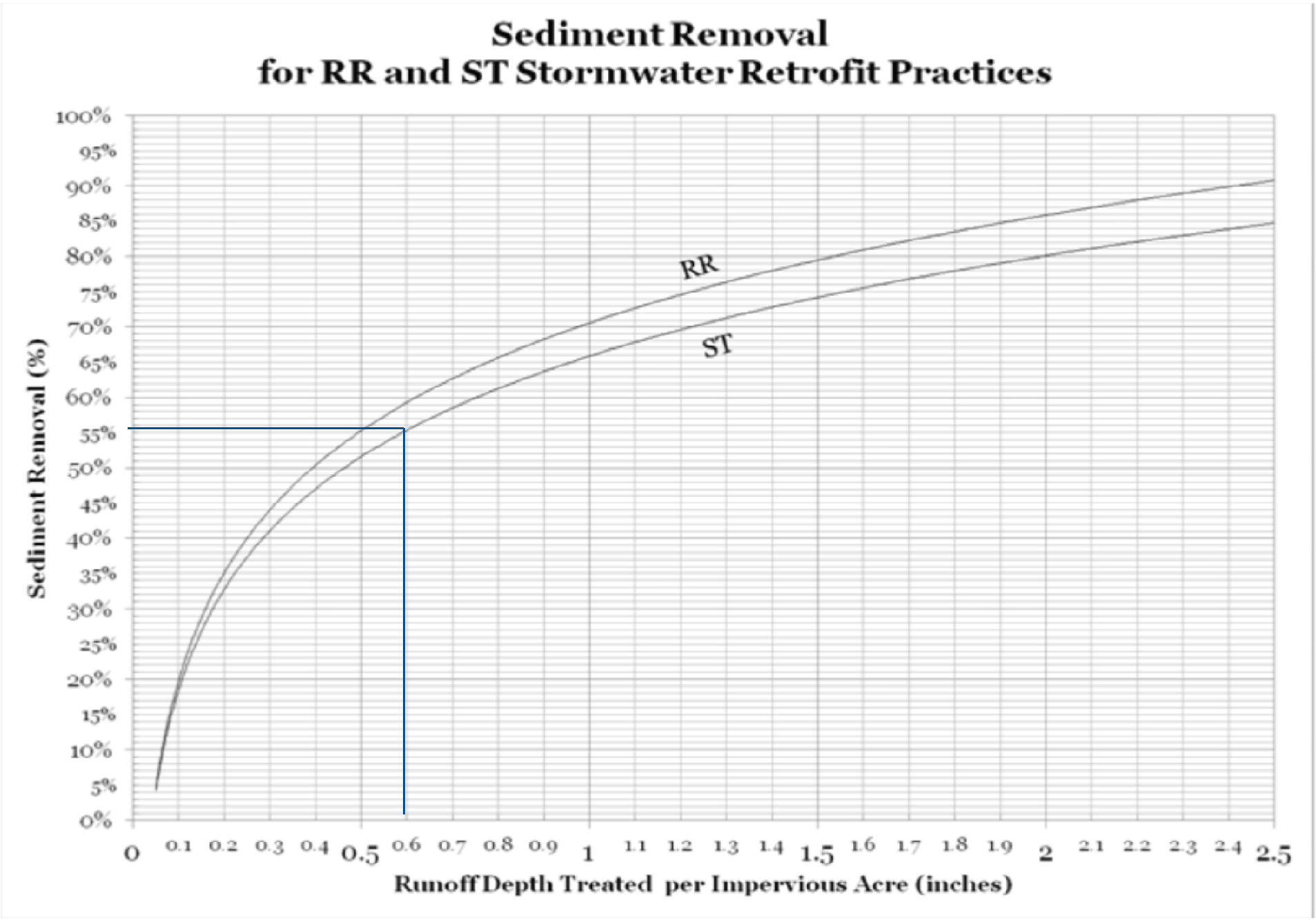
Where

RD = Runoff Depth Treated (inches)
RS = Runoff Storage (acre-feet)
IA = Impervious Acres (acres)

Wet Pond Level 1

- 22 acres total – all within regulated area
- 7.5 acres impervious
- 14.5 acres pervious
- RD = 0.6 inches
- Decide if BMP is a Runoff Reduction Practice (RR) or a Stormwater Treatment Practice (ST) from Table V.B.1

Runoff Reduction Practices (RR)	Stormwater Treatment Practices (ST)
Site Design/Non-Structural Practices	Constructed Practices
Landscape Restoration/Reforestation	Constructed Wetlands
Riparian Buffer Restoration	Filtering Practices (aka Constructed Filters, Sand Filters, Stormwater Filtering Systems)
Rooftop Disconnection (aka Simple Disconnection to Amended Soils, to a Conservation Area, to a Pervious Area, Non-Rooftop Disconnection)	Proprietary Practices (aka Manufactured BMPs)
Sheetflow to Filter/Open Space* (aka Sheetflow to Conservation Area, Vegetated Filter Strip)	Wet Ponds (aka Retention Basin)
All Environmental Site Design BMPS	Wet Swale
Constructed Practices	
Bioretention or Rain Garden (Standard or Enhanced)	
Dry Swale	
Expanded Tree Pits	
Grass Channels (w/ Soil Amendments, aka Bio-swale, Vegetated Swale)	
Green Roof (aka Vegetated Roof)	
Green Streets	
Infiltration (aka Infiltration Basin, Infiltration Bed, Infiltration Trench, Dry Well/Seepage Pit, Landscape Infiltration)	
Permeable Pavement (aka Porous Pavement)	
Rainwater Harvesting (aka Capture and Re-use)	
*May include a berm or a level spreader	


Sediment Removal
for RR and ST Stormwater Retrofit Practices
Sediment Removal (%)
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
RR
ST
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4
2.5
Runoff Depth Treated per Impervious Acre (inches)

TSS Removal Efficiency

- According to the curve for a Runoff Depth of 0.6 inches, the Sediment removal efficiency for the constructed level 1 wet pond is 55%

- Once the Sediment removal percentage is known, the calculations for Total Sediment reductions can be done in the same way as the Nitrogen and Phosphorous calculations, whether the Clearinghouse or Chesapeake Bay Program numbers are used

Wet Pond Level 1

Use the 2009 EOS loading rates from Table 2a

Sediment impervious loading:

7.5 acres * 676.94 lbs/acre/yr = 5077.1lbs/yr

Sediment pervious loading:

14.5 acres * 101.08 lbs/acre/yr = 1465.7 lbs/yr

Wet Pond Level 1

Sediment Removal Efficiency Calculation

Impervious: 5077.1 lbs/yr * 0.55 = 2792.4 lbs/yr

Pervious: 1465.7 lbs/yr * 0.55 = 806.1lbs/yr

Total Sediment removed by this BMP:

2792.4 lbs/yr + 806.1 lbs/yr = 3598.5 lbs/yr

Remaining Reduction Required

- Total Sediment reduction required: 17087.6 lbs/yr

  17087.6 lbs/yr – 3598.5 lbs/yr = 13489.1 lbs/yr

Remaining Reductions Required for all POCs

	Nitrogen (lbs/yr)	Phosphorous (lbs/yr)	Sediment (lbs/yr)
Clearinghouse Efficiencies	144.2	22.3	13489.1
Chesapeake Bay Program Efficiencies	144.2	22.3	13161.9

Chesapeake Bay Program Retrofit Curves

- If the BMP does not meet the design criteria listed for the Virginia BMP Clearinghouse or Chesapeake Bay Program the Chesapeake Bay Program Retrofit Curves must be used

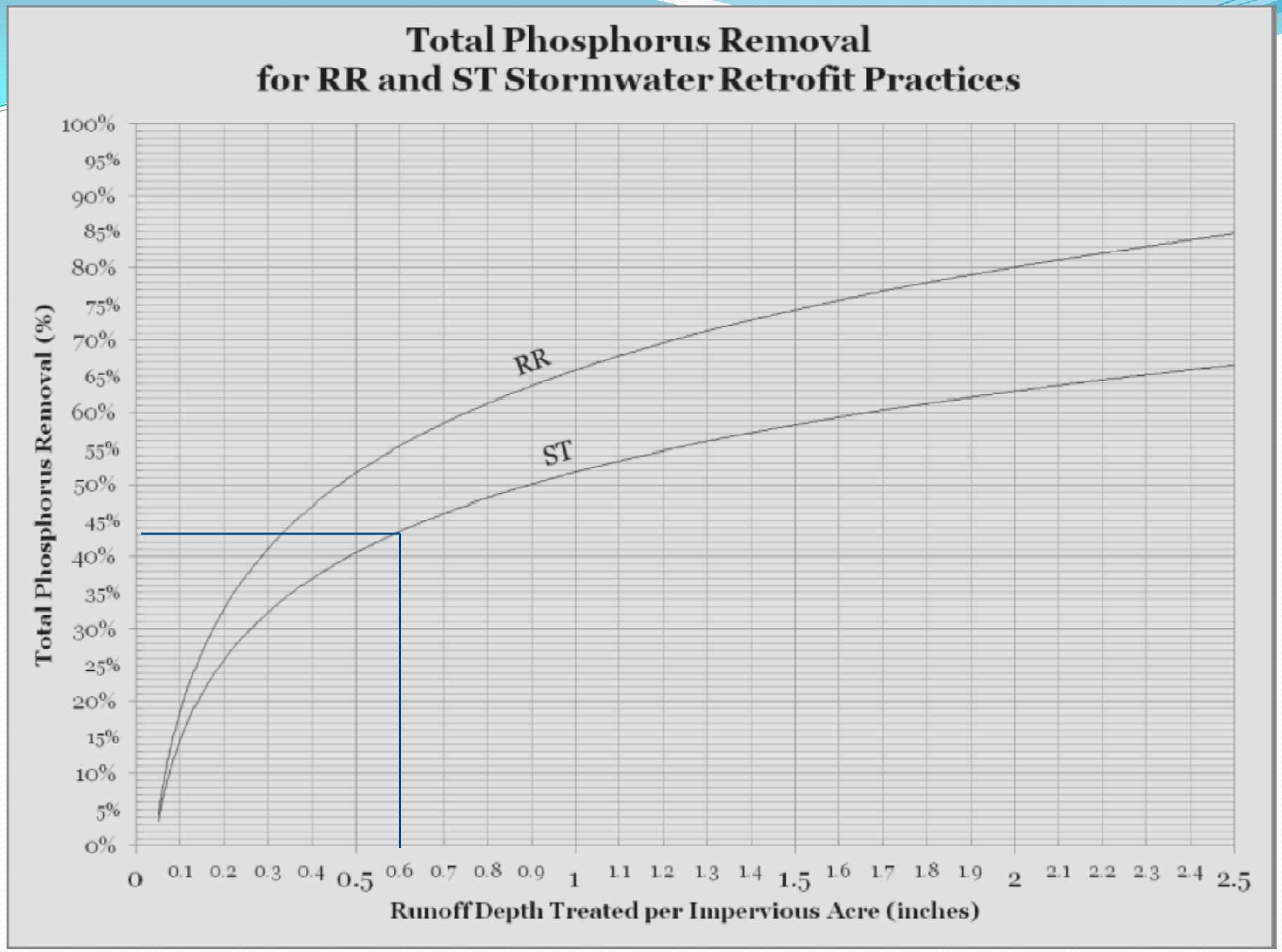
Chesapeake Bay Program Retrofit Curves

- The procedure for determining the POC reduction efficiencies utilizing the Chesapeake Bay Program Retrofit Curves is identical to utilizing the curves to find the TSS reduction values when using the BMP Clearinghouse Data.

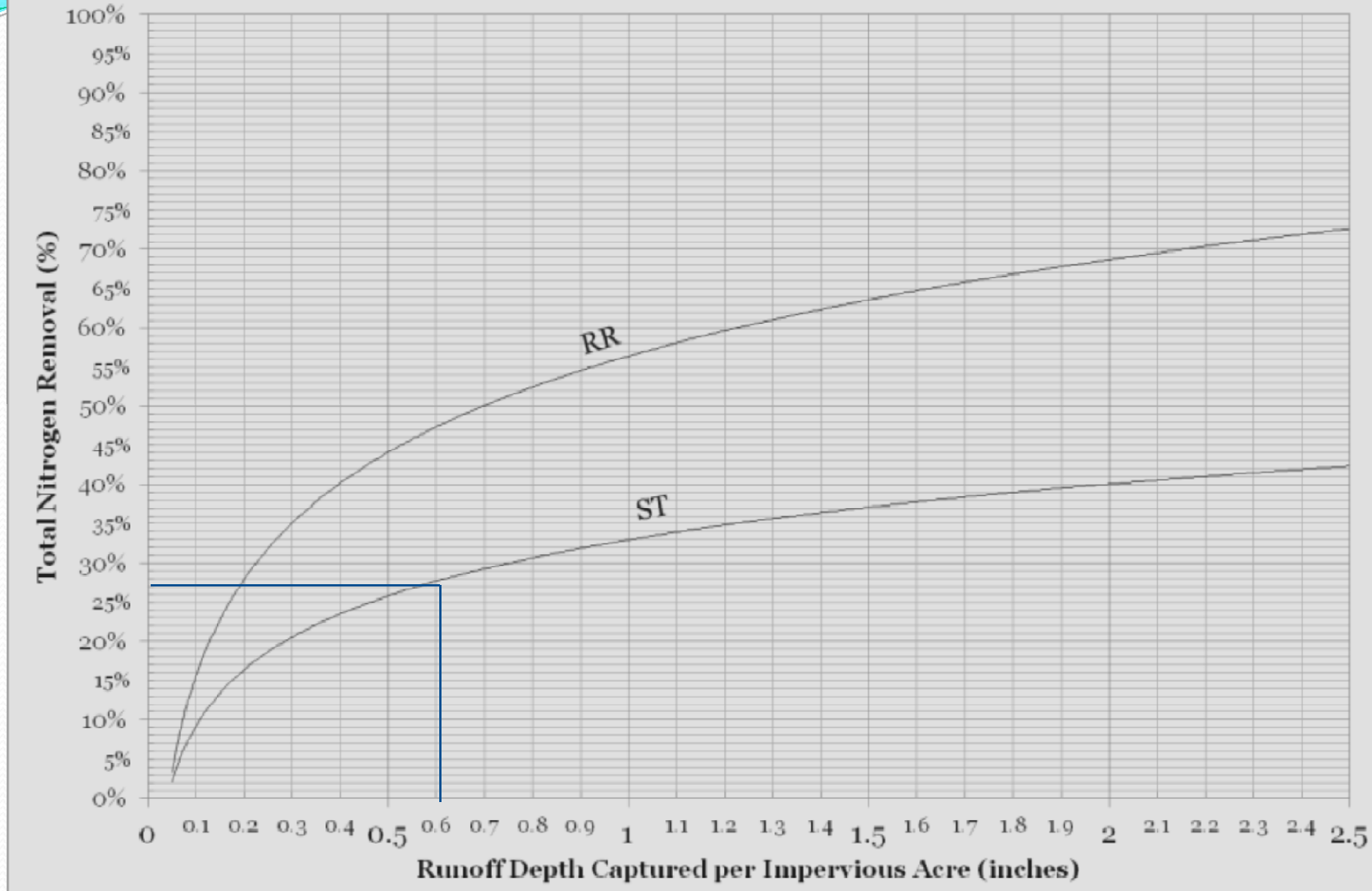
Wet Pond Level 1

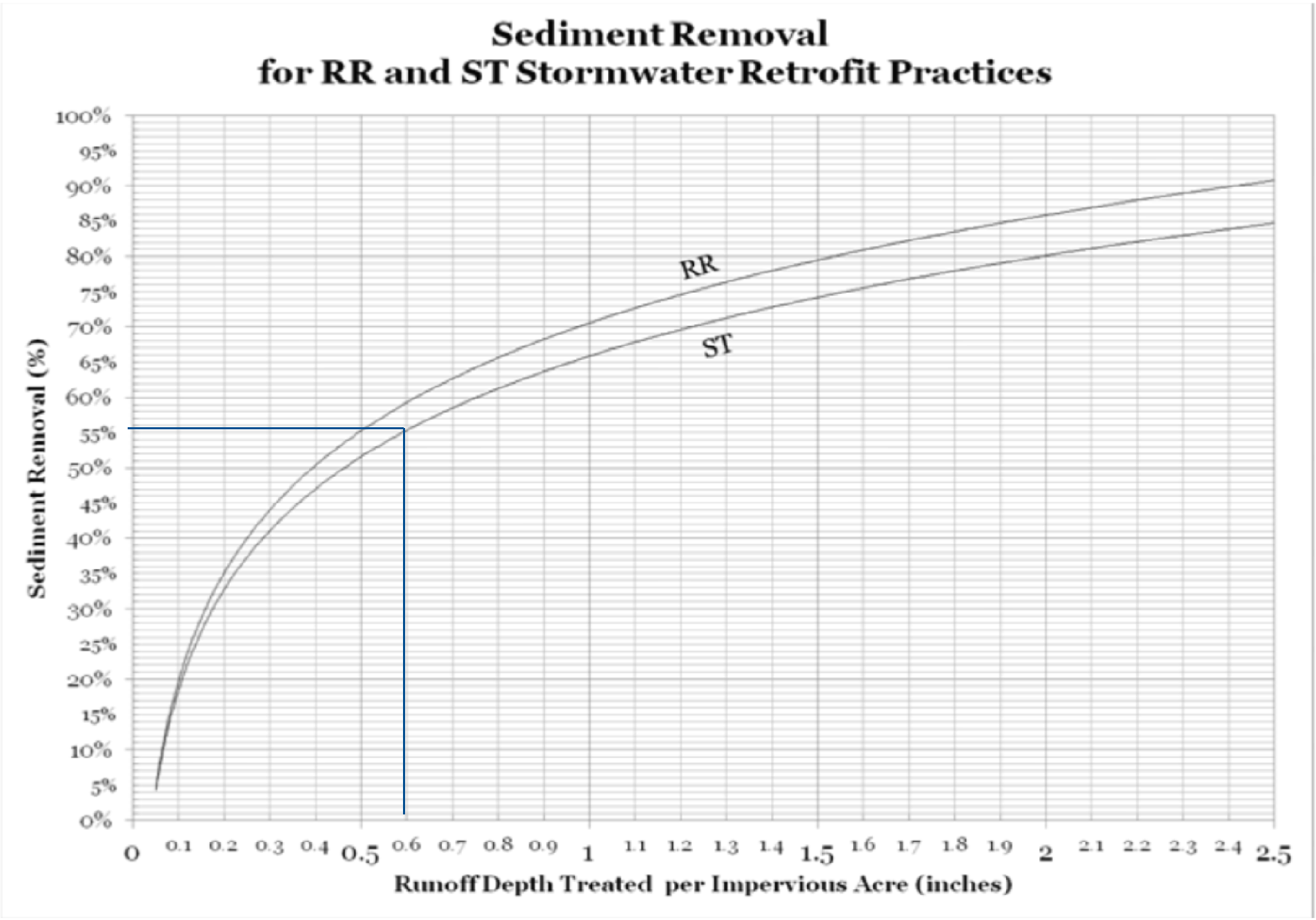
Necessary information for utilizing the curves:

- 22 acres total – all within regulated area
- 7.5 acres impervious
- 14.5 acres pervious
- RD = 0.6 inches
- Decide if BMP is a Runoff Reduction Practice (RR) or a Stormwater Treatment Practice (ST) from Table V.B.1


Total Phosphorus Removal
for RR and ST Stormwater Retrofit Practices
Total Phosphorus Removal (%)
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
RR
ST
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4
2.5
Runoff Depth Treated per Impervious Acre (inches)

Total Nitrogen Removal for RR and ST Stormwater Retrofit Practices




Sediment Removal
for RR and ST Stormwater Retrofit Practices
Sediment Removal (%)
100%
95%
90%
85%
80%
75%
70%
65%
60%
55%
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
RR
ST
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4
2.5
Runoff Depth Treated per Impervious Acre (inches)

Reduction Efficiencies Based on Retrofit Curves

- Nitrogen – 28% reduction efficiency
- Phosphorous – 43% reduction efficiency
- Sediment – 55% efficiency

Wet Pond Level 1

Use the 2009 EOS loading rates from Table 2a

Nitrogen impervious loading:

7.5 acres * 9.39 lbs/acre/yr = 70.4 lbs/yr

Nitrogen pervious loading:

14.5 acres * 6.99 lbs/acre/yr = 101.4 lbs/yr

Wet Pond Level 1

Nitrogen Removal Efficiency Calculation

Impervious: 70.4 lbs/yr * 0.28 = 19.7 lbs/yr

Pervious: 101.4 lbs/yr * 0.28 = 28.4 lbs/yr

Total Nitrogen removed by this BMP:

19.7 lbs/yr + 28.4 lbs/yr = 48.1 lbs/yr

Wet Pond level 1

Use the 2009 EOS loading rates from Table 2a

Phosphorous impervious loading:

7.5 acres * 1.76 lbs/acre/yr = 13.2 lbs/yr

Phosphorous pervious loading:

14.5 acres * 0.5lbs/acre/yr = 7.3 lbs/yr

Wet Pond Level 1

Phosphorous Removal Efficiency Calculation

Impervious: 13.2 lbs/yr * 0.43 = 5.7 lbs/yr

Pervious: 7.3 lbs/yr * 0.43 = 3.1 lbs/yr

Total Phosphorous removed by this BMP:

5.7lbs/yr + 3.1 lbs/yr = 8.8 lbs/yr

Wet Pond Level 1

Use the 2009 EOS loading rates from Table 2a

Sediment impervious loading:

7.5 acres * 676.94 lbs/acre/yr = 5077.1lbs/yr

Sediment pervious loading:

14.5 acres * 101.08 lbs/acre/yr = 1465.7 lbs/yr

Wet Pond Level 1

Sediment Removal Efficiency Calculation

Impervious: 5077.1 lbs/yr * 0.55 = 2792.4 lbs/yr

Pervious: 1465.7 lbs/yr * 0.55 = 806.1lbs/yr

Total Sediment removed by this BMP:

2792.4 lbs/yr + 806.1 lbs/yr = 3598.5 lbs/yr